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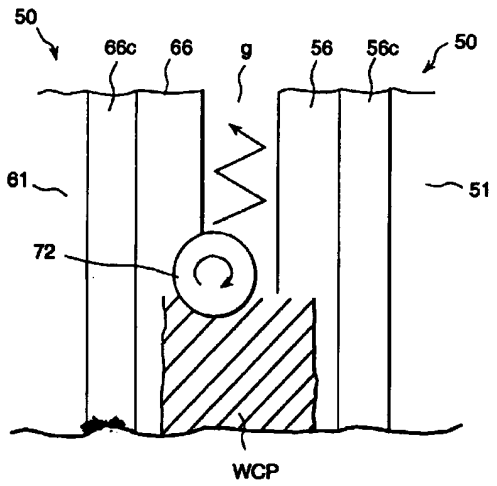
(54) Friction stir welding method and friction stir welding apparatus

(57) End portions of welding portions of extruded frame members 50 and 60 have thick thickness portions 56 and 66 which project to an outer side. A rotary body 70 is inserted to the thick thickness portions 56 and 66 and is rotated and carries out the friction stir welding. Under a large diameter portion 71 of the rotary body 70 is positioned to an outer side from an extension line of an outer face of plates 51 and 61 of the extruded frame members 50 and 60 and the rotary body 70 is rotated. Further, to a direction orthogonal to a welding line the rotary body 70 is carried out a reciprocating motion and is moved along to the welding line. Accordingly, the friction stir welding can be carried out fully. In the friction stir welding due to a rotation of the rotary body 70, even a gap g between two extruded frame members to be subjected to welding is large, it enable to carry out the friction stir welding.

FIG. 2



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Description

Background of the Invention:

[0001] The present invention relates to a friction stir welding method and a friction stir welding apparatus, and particular to a friction stir welding method and a friction stir welding apparatus wherein a friction stir welding method and an apparatus for carrying out the friction stir welding is used for, for example, in a welding manner such as an aluminum alloy material frame member etc. for use in a side body structure of a car body in a railway vehicle.

[0002] A friction stir welding method is a method in which by rotating a round rod (it is called as a rotary body) inserted in a welding portion to be subjected to welding and moving the rotary body along to a welding line. A material existed in the welding portion to be subjected to welding is exothermal heated and softened and further elastically fluidized and then the material is carried out a solid phase welding according to the friction stir welding.

[0003] The rotary body used in the friction stir welding method and the apparatus for carrying out the friction stir welding comprises a small diameter portion which is inserted fully to the welding portion to be subjected to welding and a large diameter portion which is positioned at an outside portion of the small diameter portion and this large diameter portion of the rotary body is inserted a little also to the welding portion to be subjected to welding. The small diameter portion and the large diameter portion of the rotary body are arranged at the same axis. Both sides of the small diameter portion and the large diameter portion of the rotary body are rotated.

[0004] A boundary face portion between the small diameter portion and the large diameter portion of the rotary body is inserted also a little into the welding portion to be subjected to welding. In general, a gap is formed between side vertical wall portions of two welding members to be welded. The material existed in the welding portion to be subjected to welding in the gap is blown off and the material to be welded surrounding the gap becomes thin.

[0005] Accordingly, an end portion of the welding member to be welded is formed with a thick thickness portion of the welding member to be welded, namely the welding member to be welded has the thick thickness portion at the end portion.

[0006] This friction stir welding technique about the two members to be welded having the thick thickness portion at the end portion thereof is shown in Japanese application announcement publication No. Hei 7-505090 (EP 0615480 B1), "Welding & Metal Fabrication" January 1995, pages 13, 14 and 16, and EP 0797043 A2.

[0007] Further, the material of the member to be welded is shown in the above stated Japanese application announcement publication No. Hei 7-505090. As to the material to be subjected to welding, and the material, a size, a rotation speed, and a moving speed of the rotary body is shown in "Study of Friction Stir Welding" at Welding Association Japan Meeting Symposium Summary : No. 56 ('95 - 4), pages 208 and 209.

[0008] The friction stir welding technique is one welding manner in which the material of the member to be subjected to welding is softened and welded, but there is no supplement of the metal. Accordingly, in a case two members to be welded are welded by abutting them, when there exists a gap formed between the two members to be welded, then a thickness of a welding portion to be subjected to welding will become thin. In the above stated EP 0797043 A2, forming the thickness of the members to be welded of the welding portion to be subjected to welding thick, and to the gap formed between two members to be welded the metal from the thick thickness portion of the member to be welded will be supplemented.

[0009] However, when a size (a horizontal width) of the gap formed between the two members to be welded is larger than a diameter of the small diameter portion of the rotary body, it is impossible to carry out the friction stir welding.

[0010] Even when the size of the above gap is smaller than the diameter of the small diameter portion of the rotary body, the friction stir welding will become insufficient according to an approach to the diameter of the small diameter portion of the rotary body. The size of the above stated gap is determined easily by the manufacture accuracy of the members to be welded.

[0011] In particular, for example, such as in a case where a side body structure of a car body of a railway vehicle is manufactured by welding aluminum alloy long longitudinal length extruded frame members, when it tries to weld the long length frame members, since a size of a gap may become easily large, the friction stir welding becomes difficult.

[0012] When the member to be welded is long length one, since the manufacture accuracy of the welding portion to be subjected to welding of the members to be welded relates largely, the management of the size of the gap becomes difficult, and then the friction stir welding technique becomes difficult.

[0013] Further, it relates to the accuracy for fixing the members to be welded to a frame stand. For example, a longitudinal length of the extruded frame member for the side body structure of the car body of the railway vehicle is about from 20 m to 25 m.

Summary of the Invention:

[0014] An object of the present invention is to provide a friction stir welding method and a friction stir welding apparatus where even a size of a gap of two members to be welded is large, the friction stir welding can be easily carried out.

[0015] The above stated object is attained by a method of a friction stir welding, wherein rotating and moving a rotary body while reciprocating said rotary body to an orthogonal direction with a welding line of two welding members to be subjected to welding along to said welding line.

[0016] The above stated object is attained by a method of a friction stir welding, wherein abutting two welding members to be subjected to welding with a gap, detecting a size of said gap between said two welding members to be subjected to welding, rotating and moving a rotary body while reciprocating said rotary body to an orthogonal direction with a welding line of said two welding members to be subjected to welding along to said welding line, and when said gap is less than a predetermined value, stopping said reciprocating motion of said rotary body.

[0017] The above stated object is attained by a method of a friction stir welding, wherein abutting thick thickness portions of two welding members be subjected to welding, each having said thick thickness portion which protrudes from one face from an end portion of said welding member to be subjected to welding, under a condition a small diameter portion of a rotary body which has said small diameter portion at a tip end of a large diameter portion of said rotary body is inserted in said thick thickness portion of said welding member to be subjected to welding and further, between an extension line of said face of said one welding member to be subjected to welding except for said thick thickness portion of said welding portion to be subjected to welding and an apex of said thick thickness portion of said one welding member to be subjected to welding, under a condition positioning a boundary face portion of said large diameter portion and said small diameter portion of said rotary body, rotating and moving a rotary body while reciprocating said rotary body to an orthogonal direction with a welding line of two welding members to be subjected to welding along to said welding line.

[0018] The above stated object is attained by a method of a friction stir welding, wherein when end portions of two welding members to be subjected to welding, each having a thick thickness portion which protrudes from one face of said end portion of said welding member to be subjected to welding, are abutted with a gap, positioning a portion which is protruded directing for said thick thickness portion of another said welding member to be subjected to welding from said thick thickness portion of one said welding member to be subjected to welding to cover said gap between said two thick thickness portions of said two welding members to be subjected to welding, under a condition a small diameter portion of a rotary body which has said small diameter portion at a tip end of a large diameter portion of said rotary body is inserted said abutting portion including said thick thickness portion of said welding member to be subjected to welding and further, between an extension line of said face of said one welding member to be subjected to welding except for said thick thickness portion of said welding member to be subjected to welding and an apex of said thick thickness portion of said welding member to be subjected to welding, under a condition by positioning a boundary face portion of said large diameter portion and said small diameter portion of said rotary body, and rotating and moving said rotary body while reciprocating said rotary body to an orthogonal direction with a welding line of two welding members to be subjected to welding along to said welding line.

[0019] The above stated object is attained by an apparatus of a friction stir welding, comprising wherein a rotation apparatus for rotating a rotary body having a small diameter portion at a tip end of a large diameter portion of said rotary body, a drive apparatus for reciprocating said rotary body, and a running body moving said rotation apparatus and said drive apparatus to an orthogonal direction against to a reciprocating motion of said rotary body.

Brief Description of Drawings:

[0020]

Fig. 1 is a longitudinal cross-section view of a rotary body and a welding portion to be subjected to welding of two extruded frame members to be welded for carrying out a friction stir welding method of one embodiment according to the present invention;

Fig. 2 is a plan view showing a friction stir welding method in which a friction stir welding is carried on a welding portion to be subjected to welding of two extruded frame members to be welded using a rotary body which is moved in zigzag form;

Fig. 3 is a longitudinal cross-section view showing two extruded frame members to be welded having a welding portion after the friction stir welding technique has carried out;

Fig. 4 is an oblique view showing a friction stir welding apparatus for carrying out on two extruded frame members to be welded having a rotary body of one embodiment according to the present invention;

Fig. 5 is a longitudinal cross-sectional view showing the friction stir welding apparatus having the rotary body shown in Fig. 4;

Fig. 6 is an oblique view showing a car body of a railway vehicle having frame members in which the friction stir welding technique has carried out;

Fig. 7 is a longitudinal cross-sectional view showing an essential portion of two extruded frame members having a welding portion to be subjected to welding of a friction stir welding method of another embodiment according to the present invention.

Fig. 8 is a longitudinal cross-sectional view showing an essential portion of two extruded frame mem-

bers having a welding portion to be subjected to welding of a friction stir welding method of a further embodiment according to the present invention; and

Fig. 9 is a right side view showing one frame member to be welded having a rib shown in Fig. 8.

Description of the Invention:

[0021] One embodiment a friction stir welding method which is applied to two extruded frame members of a car body of a railway vehicle will be explained referring to from Fig. 1 to Fig. 6.

[0022] In Fig. 6, a car body of a railway vehicle comprises a side body structure 41, a roof body structure 42, a floor body structure 43, a longitudinal direction end portion end body structure 44. The side body structure 41 is constituted by arranging plural extruded frame members 50 and 60 in parallel and plural extruded frame members 50 and 60 have carried out using a friction stir welding method according to the present invention.

[0023] The friction stir welding method is carried out on the side body structure 41 of the car body of the railway vehicle as shown in Fig. 1. The roof body structure 42 and the floor body structure 43 are constituted similarly. A connection between the side body structure 41 and the roof body structure 42 and a connection between the side body structure 41 and the roof body structure 43 are carried out by means of MIG welding manner etc..

[0024] Fig. 1 shows the welding portion to be subjected to welding of the extruded frame members 50 and 60 for constituting the side body structure 41 and also a rotary body 70 structure. Each of the extruded frame members 50 and 60 is made of an aluminum alloy long length extruded frame member having a longitudinal length of about from 20 m to 25 m, for example. The long length extruded frame members 50 and 60 comprise plates 51 and 61 and plural ribs 53 and 63 which are installed on one side of these plates 51 and 61. The sides of the ribs 53 and 63 form an inner side of the car body of the railway vehicle. The ribs 53 and 63 are connected to the already known post member.

[0025] End portions of the plates 51 and 61 of the two extruded frame members 50 and 60, namely the welding portion to be subjected to welding is protruded to an opposite side to the ribs 53 and 63 and form thick thickness portions 56 and 66. The apexes of the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60 are connected to the plates (non-protrusion portions) 51 and 61 through inclination face portions 56c and 66c.

[0026] In the friction stir welding method of this embodiment according to the present invention, the welding portion to be subjected to welding indicates two opposite parts of the apexes of the thickness portion 56 and 66, two opposite vertical side end walls of the thickness portions 56 and 66, and two opposite vertical side end walls of the plates 51 and 61 which are connected continuously to the two opposite vertical side end walls of the thickness portions 56 and 66, for example.

[0027] The above stated welding portion to be subjected to welding has a predetermined interval value G or a size (a horizontal direction width) G of a gap g, before the practice of the friction stir welding method. In this embodiment, the size G of the gap is 2 mm at maximum, for example, this size G of the gap is desirable to be a small value.

[0028] The two extruded frame members 50 and 60 are mounted on a frame stand 30 by abutting the end portions of the welding portion to be subjected to welding and fixed to the frame stand 30. Then the welding portion to be subjected to welding is formed by arranging the two extruded frame members 50 and 60 on the frame stand 30. Further, the extruded frame members 50 and 60 are welded each other with a predetermined interval at the portions of the thick thickness portions 56 and 66 according to the friction stir welding.

[0029] With this construction, the interval of the welding portion to be subjected to welding of the two extruded frame members 50 and 60 is managed at a predetermined value. Since the interval of the welding portion to be subjected to welding of the two extruded frame members 50 and 60 is managed, the two end portions of the welding portion to be subjected to welding are made to contact (the interval is zero) or lessen the size G of the gap g between the two end portions. When the size G of the gap g is small value, the reciprocating amount of the rotary body 70 can be made small, as a result the welding time can be shortened.

[0030] However, the size of G of gap g is determined by the manufacture accuracy of the welding portion to be subjected to welding of the two extruded frame members 50 and 60. When the end portions of the two extruded frame members 50 and 60 is formed with a wave form along to direction of a welding line (an extruded direction of the extruded frame member or a longitudinal direction of the extruded frame member), it is difficult to fix the extruded frame members 50 and 60 to the frame stand 30 to make to lessen the size G of the gap g. In particular, in a case of the longitudinal long length member, the manufacture accuracy of the two extruded frame members 50 and 60 is inferior and it is difficult to set the size G of the gap g at a predetermined value.

[0031] When the size G of the gap g is larger than a diameter d of a small diameter portion 72 of a rotary body 70, it is impossible to carry out the friction stir welding. Even the size G of the gap g is smaller than the diameter d of the small diameter portion 72 of the rotary body 70, the friction stir welding becomes insufficiently when the size G of the gap g approaches nearly to a diameter d of the small diameter portion 72 of the rotary body 70.

[0032] The rotary body 70 comprises a large diameter

portion 71 and the small diameter portion 72 at a tip end of the large diameter portion 71. The diameter D of the large diameter portion 71 of the rotary body 70 is about 20 mm, for example, and a diameter d of the small diameter portion 72 of the rotary body 70 is 6 mm, for example. The rotary body 70 is inserted from the apex side of the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60 and is rotated.

[0033] During the insertion of the rotary body 70, a tip end (a lower end) of the small diameter portion 72 of the rotary body 70 approaches the sides of the ribs 53 and 63 (the frame stand 30 side) of the thick thickness portions 56 and 66. A height of the plates 51 and 61 is 3.3 mm, for example.

[0034] A boundary face portion 73 between the large diameter portion 71 and the small diameter portion 72 of the rotary body 70 is positioned at a position (a horizontal direction line) 73b which is an outer side (the apex side of the thick thickness portions 56 and 66) from the outer faces (the faces of the plates 51 and 61 opposite to the ribs 53 and 63) of the plates 51 and 61. In other words, the boundary face portion 73 is not inserted to go beyond the position (the horizontal direction line) 73b.

[0035] A rotation center of the rotary body 70 is positioned at an intermediate position (an intermediate portion of the gap g) between the end portions of the two extruded frame members 50 and 60 to be welded. A sensor (not shown in figure) detects corner portions of the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60 and further detects the size G of the gap g. Then the rotation center of the rotary body 70 is positioned at the intermediate portion (the welding line) between the corner portions of the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60.

[0036] Since the large diameter potion 71 of the rotary body 70 is inserted in the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60, a soften metal from the two extruded frame members 50 and 60 moves toward the gap G, the metal becomes one for connecting the extruded frame members 50 and 60 to be welded and then welding portion to be subjected to welding is welded fully by the metal. An excessive metal is blown as a facet.

[0037] Fig. 1 and Fig. 2 show a case where the size G of the gap g between the extruded frame members 50 and 60 to be welded is large, in other words the horizontal width of the welding portion to be subjected to welding is large. Under a condition the rotary body 70, as stated in above, is inserted to the thick thickness portions 56 and 66 of the extruded frame members 50 and 60, while by rotating the rotary body 70 and moving along to the gap g (namely, the welding line), and the extruded frame members 50 and 60 are welded. In this time, the rotary body 70 is moved reciprocating to a direction (in Fig. 1, a right and left direction) orthogonal against the welding line. Accordingly, the rotary body 70 is moved in a zigzag from as shown in Fig. 2. Then the friction stir welding manner is carried out on the welding portion to be subjected to welding using the rotary body 70.

[0038] As stated in above, an overlap dimension between the rotary body 70 and one thick thickness portion 56 or 66 can be made similar to a case where the size G of the gap g is small. Further, an overlap dimension of other thin thickness portion 66 or 56 can be made similar to a case where the size G of the gap g is small. As a result, the extruded frame members 50 and 60 to be welded can be welded fully according to the friction stir welding method using the zigzag move rotary body 70.

[0039] A connection condition of the extruded frame members 50 and 60 after the friction stir welding will be shown in Fig. 3. Fig. 3 shows schematically the two extruded frame members 50 and 60 after the friction stir welding. WP indicates the welding connection portion in which the metal from the two extruded frame members 50 and 60 is softened by the rotary body 70 and forms the welding connection portion WP between the two extruded frame members 50 and 60 including the welding portion to be subjected to welding.

[0040] After the friction stir welding, the left-over thick thickness portions 56 and 56 of the two extruded frame members 50 and 60, as shown in Fig. 3, are cut off to form the same face to the outer face of the plates 51 and 61 of the two extruded frame members 50 and 60. Accordingly, this smooth outer face can be formed as an outer face of the car body of the railway vehicle, for example.

[0041] The dimensions (the largeness) of the thick thickness portions 56 and 56 of the two extruded frame members 50 and 60 to be welded of this embodiment according to the present invention are will be explained. In a case where the two thick thickness portions 56 and 66 of the two extruded frame members 50 and 60 are abutted, as shown in Fig. 1, a horizontal direction width (W1 - G) of the apexes of the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60, in which the width W1 is 12 mm for example, is larger than the diameter d of the small diameter portion 72 of the rotary body 70 but is smaller than the diameter D of the large diameter portion 71 of the rotary body 70. A horizontal direction width (W2 - G) in a base portion of the two thick thickness portions 56 and 66 of the two extruded frame members 50 and 60, in which the width W2 is 22 mm for example, is larger than the diameter D of the large diameter portion 71 of the rotary body 70 as shown in Fig. 1.

[0042] A vertical length h (3.3 mm in this embodiment) of the small diameter portion 72 of the rotary body 70 is larger than a thickness of the plates 51 and 61 of the two extruded frame members 50 and 60. A projection dimension H (1 mm), the width W1 (12 mm) and the width W2 (22 mm) of the two extruded frame members 50 and 60 are determined taking into a consideration

from an aspect of supplement amount of the metal to the gap g.

[0043] An amount in which the rotary body 70 is moved orthogonally (in Fig. 1 and Fig. 2, the right and left direction) to the welding line is determined by the size G of the gap g and the overlap amount between the small diameter portion 72 of the rotary body 70 and the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60. A necessary amount for overlapping the small diameter portion 72 of the rotary body 70 and the thick thickness portions 56 and 66 of the two extruded frame members 50 and 60 is determined from an aspect of the friction stir welding strength.

[0044] A reciprocating speed (a move speed to a direction orthogonally (in Fig. 1 and Fig. 2, the right and left direction) to the welding line) of the rotary body 70 is to be larger than a move speed (a move speed along to the welding line) of the rotary body 70. When the rotary line 70 is moved along to the welding line, it is determined from an aspect in which a non-welding portion does not generate according to the reciprocating motion of the rotary body 70. For example, the reciprocating speed of the rotary body 70 is made two times degree against to the move speed of the rotary body 70.

[0045] In this embodiment according to the present invention, the moving speed V1 of the rotary body 70 is 60 cm/min and the rotating speed of the rotary body 70 is 1800 rpm. The reciprocating speed V2 of the rotary body 70 is determined by the moving speed V1 of the rotary body 70, the recriprocating speed V2 of the rotary body 70 relates to the size of the gap g, when the size G of the gap is 2 mm, the reciprocating speed V2 of the rotary body 70 is about 1.5-3 times, desirably about 2-3 times.

[0046] When the size G of the gap g is smaller than a predetermined value, it is unnecessary to carry out the reciprocating motion of the rotary body 70. By detecting the size of the size G of the gap g using the sensor, the necessity of the reciprocating motion (speed) of the rotary body 70 is determined. Accordingly, when the size G of the gap g is small, since the reciprocating motion of the rotary body 70 is stopped, in comparison with the practice of the reciprocating motion of the rotary body 70, the exothermic heat according to the friction stir welding can be made few.

[0047] Further, when the size G of the gap g is small, the move speed of the rotary body 70 along to the welding line can be made large. Further, when the size G of the gap g is larger than a size of the gap g for unnecessary to carry out the recriprocating motion but is not large quite, in comparison with the case of the large size of the gap g, the moving speed of the rotary body along to the welding line can be made large.

[0048] Fig. 4 and Fig. 5 show a friction stir welding apparatus for carrying out the friction stir welding. The rotary body 70 is installed on a gate type running body 110 which strides over the extruded frame members 50 and 60 fixed on the frame stand 30. The running body 110 moves under a predetermined speed to a longitudinal direction of the extruded frame members 50 and 60. A friction stir welding apparatus 120 having the rotary body 70 is installed on a beam member 111 of the running body 110. The friction stir welding apparatus 120 detects the thick thickness portions 56 and 66 of the extruded frame members 50 and 60 using a sensor and moves along to the beam member 111 to position a center of the gap g.

[0049] The friction stir welding apparatus 120 comprises a frame stand 121 to which the running body 111 runs, a rotation apparatus 130 for rotating the rotary body 70, a rail member 135 on which the rotation apparatus 130 moves freely, and a drive apparatus 136 for reciprocating the rotation apparatus 130 to a horizontal direction. The drive apparatus 136 is installed on a frame stand 121 and to connected to the rotation apparatus 130 through a joint member 137. The rotation apparatus 130 comprises an electric driven motor 131 and a reduction machine 132.

[0050] The frame stand 121 is installed on a running body (not shown in figure) which runs on the beam member 111 and a height of the frame stand 121 can be varied. To the frame stand 121 rollers (not shown in figure) are hung down which presses down the plates 51 and 61 which exist at a vicinity of the thick thickness portions 56 and 66. The extruded frame members 50 and 60 are adhered closely to the frame stand 30 by this rollers.

[0051] Further, a metal cutting-off machine (for example, an end mill machine) is installed to the frame stand 121 and positioned at a rear portion of the rotary body 70. The thick thickness portion 56 and 66 which have finished the friction stir welding is cut off by this metal cutting-off machine.

[0052] In the above stated embodiment, the thick thickness portions 56 and 66 is provided by protruding or projecting the face of the plates 51 and 61 which is opposite of the ribs, however the thick thickness portions 56 and 66 may protruded or project at the side of the ribs 53 and 63. In this case, a side having no ribs is mounted on the frame stand 30. Further, the extruded frame members 50 and 60 may employ a hollow frame member.

[0053] In another embodiment of a friction stir welding method according to the present invention shown in Fig. 7, a tip end 57 of the thick thickness portion 56 of one extruded frame member 50 is projected toward a side of another extruded frame member 60 and covers an upper portion of the gap g. When the size G of the gap g is small, the projection chip 57 overlaps to the apex of the thick thickness portion 66. Accordingly, the supplement of the metal to the gap g can be carried out easily.

[0054] In a case of a further embodiment of a s friction stir welding according to the present invention shown in Fig. 8 and Fig. 9, the extrusion directions of the two extruded frame members 150 and 160 are orthogonal.

Fig. 8 shows a condition of before the friction stir welding. Ribs 153 and 163 are provided on at one side of the extruded frame members 150 and 160. An end portion of the extruded frame member 150 constitutes a thick thickness portion 156. The thick thickness portion 156 projects directing for the extruded frame member 160 to be welded and constitutes a projection chip 157.

[0055] A projection dimension of the projection chip 157 has a length which overlaps to a plate 161 of another extruded frame member 160 when the size G of the gap g is small. When the size G of the gap g is large, the projection chip 157 overlaps to the plate. The projection chip 157 corresponds to the projection chip 57. The rib 163 at the vicinity of the extruded frame member is cut off and removed. A tip end of the projection chip 157 is formed slope-wise similarly to the thick thickness portion 156.

[0056] With the above stated construction, by inserting the rotary body 70 from the upper portion the friction stir welding is carried out, since the projection chip 157 exists at the upper portion of the gap g between the two extruded frame members 150 and 160, the metal of the projection chip 157 etc. is supplied to the gap g. Further, to the upper portion of the extruded frame member 160 the metal is supplied. Accordingly, in comparison with a non existence of the projection chip 167, a good friction stir welding can be obtained.

[0057] The above stated friction stir method and the above stated friction stir welding apparatus can be applied to a welding already well known honeycomb panels each other. The honeycomb panel comprises two face plates, a honeycomb shape core member between the two face plates and an edge member arranged at a periphery of the core member. A subject member to be subjected to welding can apply to pipes etc.. In this case, the elements such as a plate shown in the above stated embodiments can read suitably for a tube, etc..

[0058] The technical range according to the present invention will not be limited to the wordings described in the respective claim in claims and the wordings described in the item of the means for solving the problems, and it will be referred to the range in which an ordinary man belonged in this field can replace easily.

[0059] According to the present invention, even the size of the gap between two members to be welded is large, a full friction stir welding can be attained using the friction stir welding method and the apparatus for carrying out the friction stir welding according to the present invention.

Claims

1. A method of a friction stir welding, comprising rotating and moving a rotary body along a welding line of two members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line.

2. A method of a friction stir welding according to claim 1, wherein the moving speed in said orthogonal direction of said rotary body is more than two times the moving speed of said rotary body along said welding line.

3. A method of a friction stir welding, comprising opposing two members to be subjected to welding with a gap between them;

   detecting the size of said gap between said two members;
   rotating and moving a rotary body along a welding line of two members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line; and
   carrying out said reciprocating motion of said rotary body when said size of said gap is more than a predetermined value.

4. A method of a friction stir welding, comprising opposing two members to be subjected to welding with a gap between them;

   detecting the size of said gap between said two members;
   rotating and moving a rotary body along a welding line of two members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line; and
   stopping said reciprocating motion of said rotary body when said gap is less than a predetermined value.

5. A method of a friction stir welding, comprising

   opposing respective thick portions of two members to be subjected to welding, each having said thick portion thereof protruding from one face at an end portion of said member; and
   with a small diameter portion of a rotary body which has said small diameter portion at a tip end of a large diameter portion thereof inserted in said thick portion of said member and further, with a boundary face portion of said large diameter portion and said small diameter portion of said rotary body between an extension line of said face of at least one said member except for said thick portion thereof and an apex of said thick portion of said at least one member rotating and moving the rotary body along a welding line of the two members while reciprocating said rotary body in an orthogonal direction to the welding line.

6. A method of a friction stir welding, comprising

   opposing end portions of two welding members

to be subjected to welding, each having a thick portion which protrudes from one face of an end portion to be subjected to welding, with a gap between them;

positioning a portion which protrudes from said thick portion of one said member towards the other member to cover said gap between said two thick portions; and

with a small diameter portion of a rotary body which has said small diameter portion at a tip end of a large diameter portion thereof inserted in said opposed portion including said thick portion of said members and further, with a boundary face portion of said large diameter portion and said small diameter portion of said rotary body between an extension line of said face of said one member except for said thick portion thereof and an apex of said thick portion of said welding member, rotating and moving the rotary body along a welding line of the two members, while reciprocating said rotary body in an orthogonal direction to the welding line.

7. A method of a friction stir welding, comprising

opposing an when end portion of first member to be subjected to welding and an end portion of a second member to be subjected to welding with overlapping of a portion which projects towards one said member from a thick portion which projects above one face of the other member in the thickness direction, and

with a small diameter portion of a rotary body which has said small diameter portion at a tip end of a large diameter portion thereof inserted from a side of the apex of said thick portion to said opposed portion, and further with a boundary face portion of said large diameter portion and said small diameter portion of said rotary body between an extension line of said face of said other member except for said thick portion thereof and said apex of said thick portion, rotating and moving the rotary body along a welding line of two members while reciprocating said rotary body in an orthogonal direction to the welding line.

8. An apparatus for friction stir welding, comprising:

a rotation apparatus for rotating a rotary body having a small diameter portion at a tip end of a large diameter portion of said rotary body;

a drive apparatus for reciprocating said rotary body; and

traversing means for moving said rotation apparatus and said drive apparatus in an orthogonal direction relative to said reciprocating motion of said rotary body.

9. A method of a friction stir welding for extruded frame members having plural ribs on only one face of a plate, wherein,

at an end portion of said plate at least one said extruded frame member has a thick portion which projects from said one face or another face of said plate and has a protrusion which protrudes from a side of an apex of said thick portion to a direction separating said end portions;

the step of rotating and moving a rotary body along a welding line of the two members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line.

10. A method of a friction stir welding of frame members, comprising

opposing thick portions of two frame members to be subjected to welding with a gap between them, said thick portions being provided on end portions of each of said two frame members; and

rotating and moving a rotary body along a welding line of the two frame members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line.

11. A method of friction stir welding for frame members comprising

opposing thick portions of two frame members to be subjected to welding with a gap between them, said thick portions being provided at an end portion of each of said two frame members;

detecting a size of said gap between said two frame members;

rotating and moving a rotary body along the welding line of the two members to be welded, while reciprocating said rotary body in an orthogonal direction to the welding line; and

carrying out said reciprocating motion of said rotary body when said size of said gap is more than a predetermined value.

FIG. 1

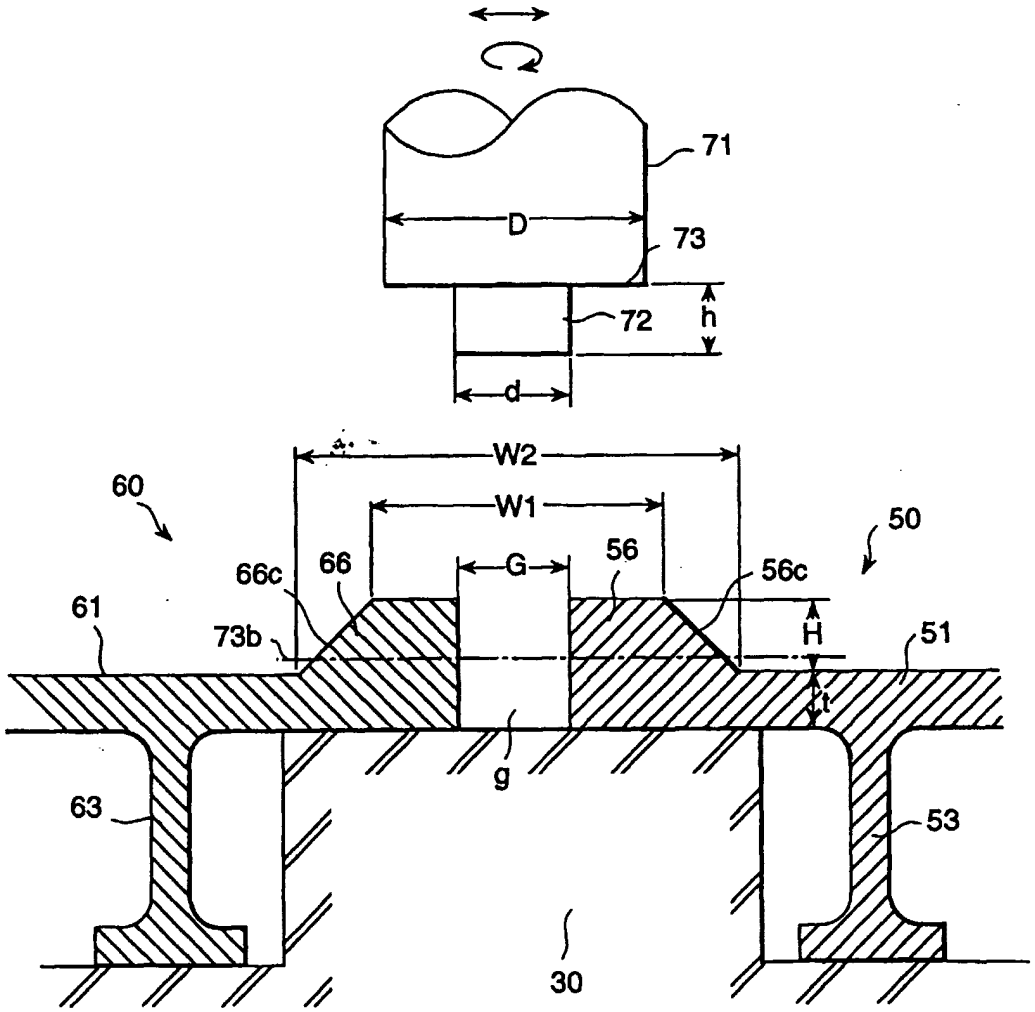


FIG. 2

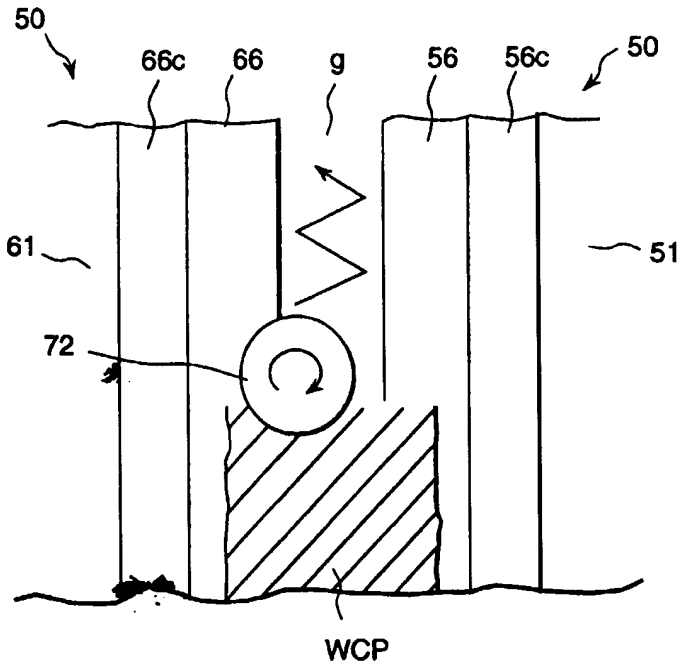


FIG. 3

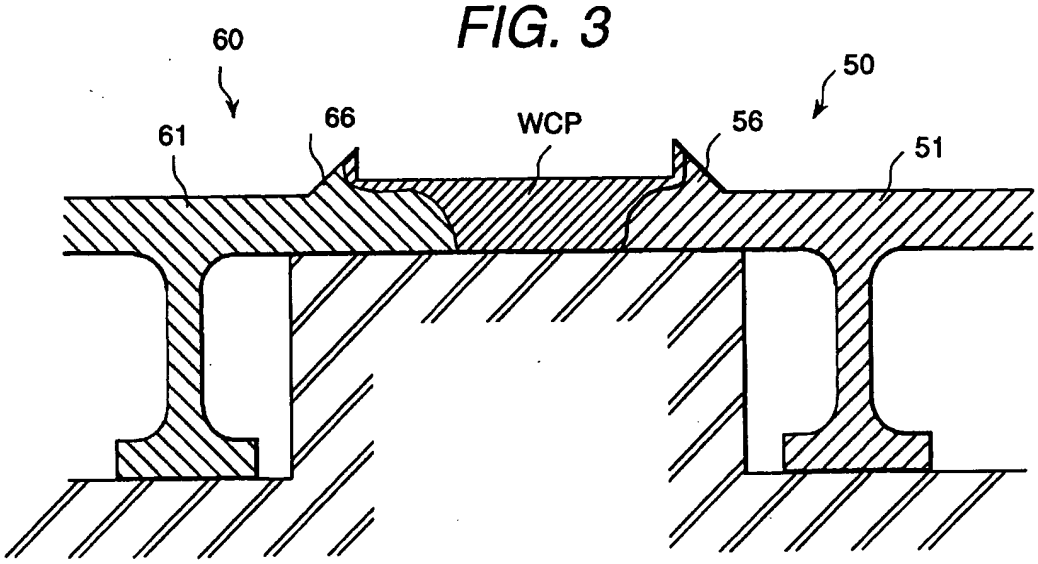


FIG. 4

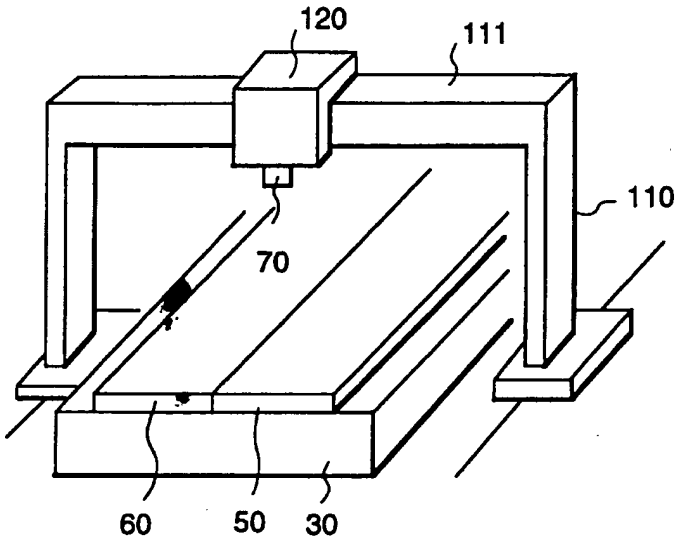


FIG. 5

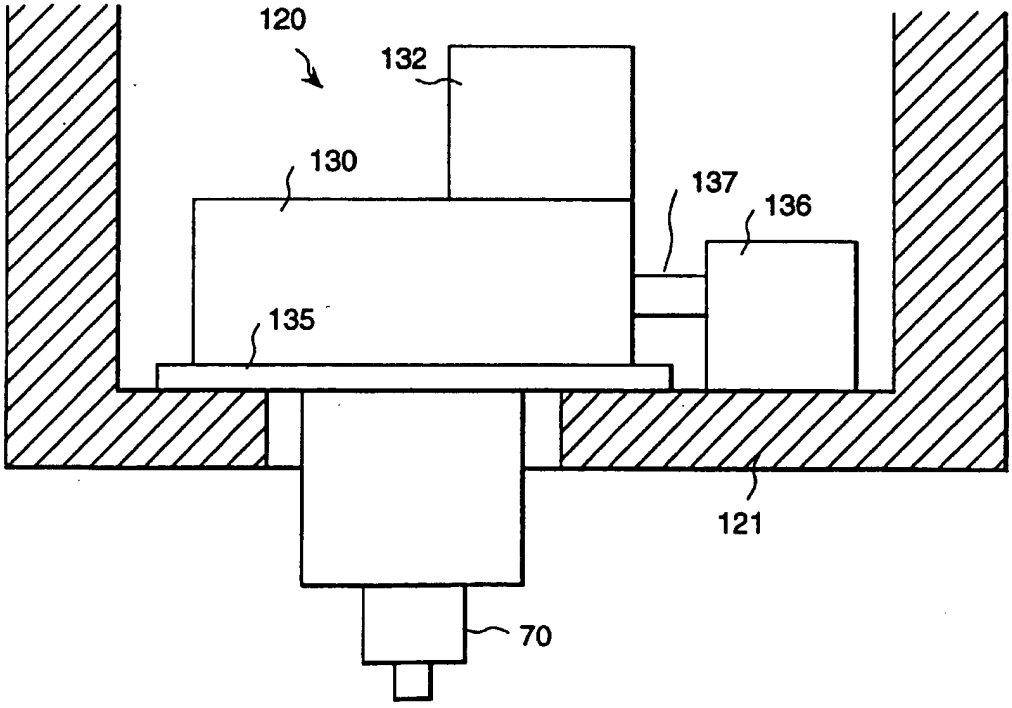


FIG. 6

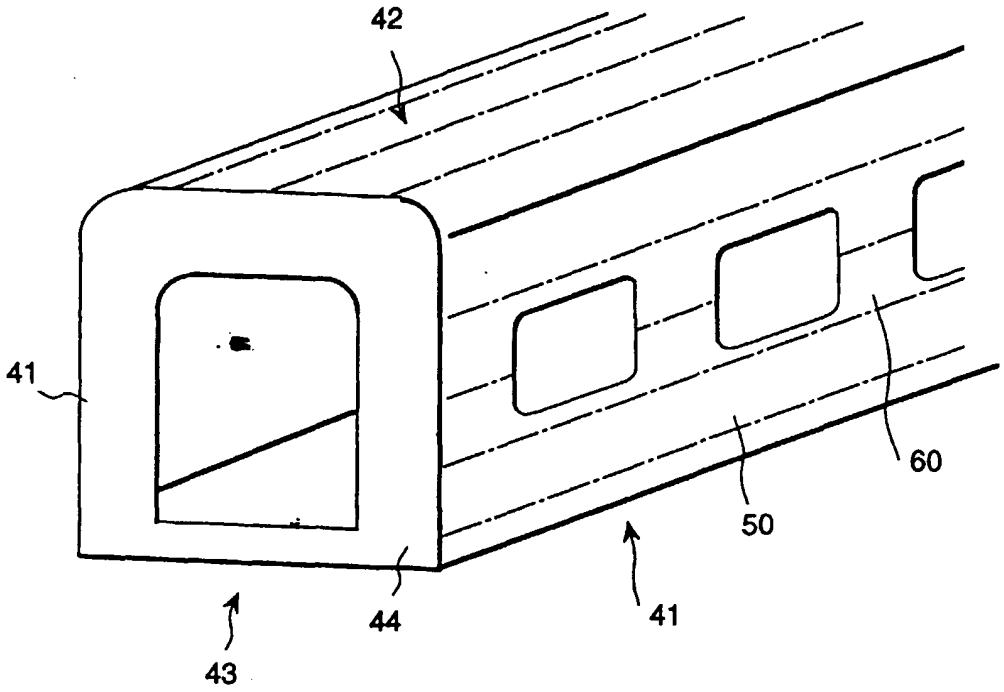


FIG. 7

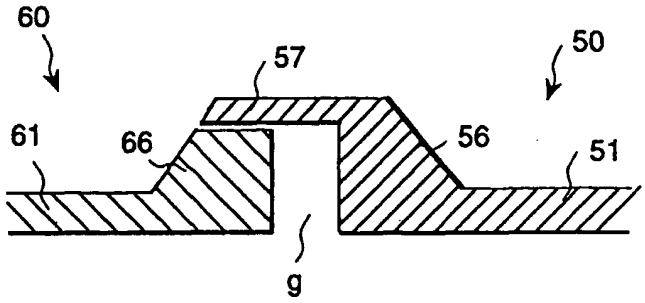


FIG. 8

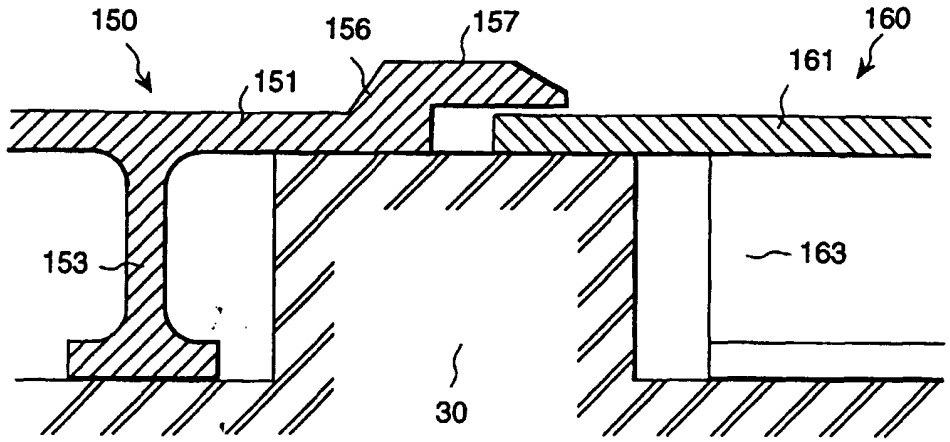
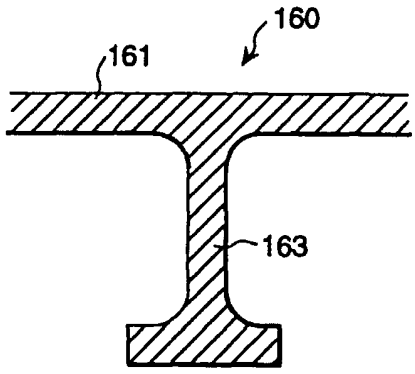


FIG. 9



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EUROPEAN SEARCH REPORT

Application Number
EP 99 30 2352

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B23K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 July 1999	Herbreteau, D

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